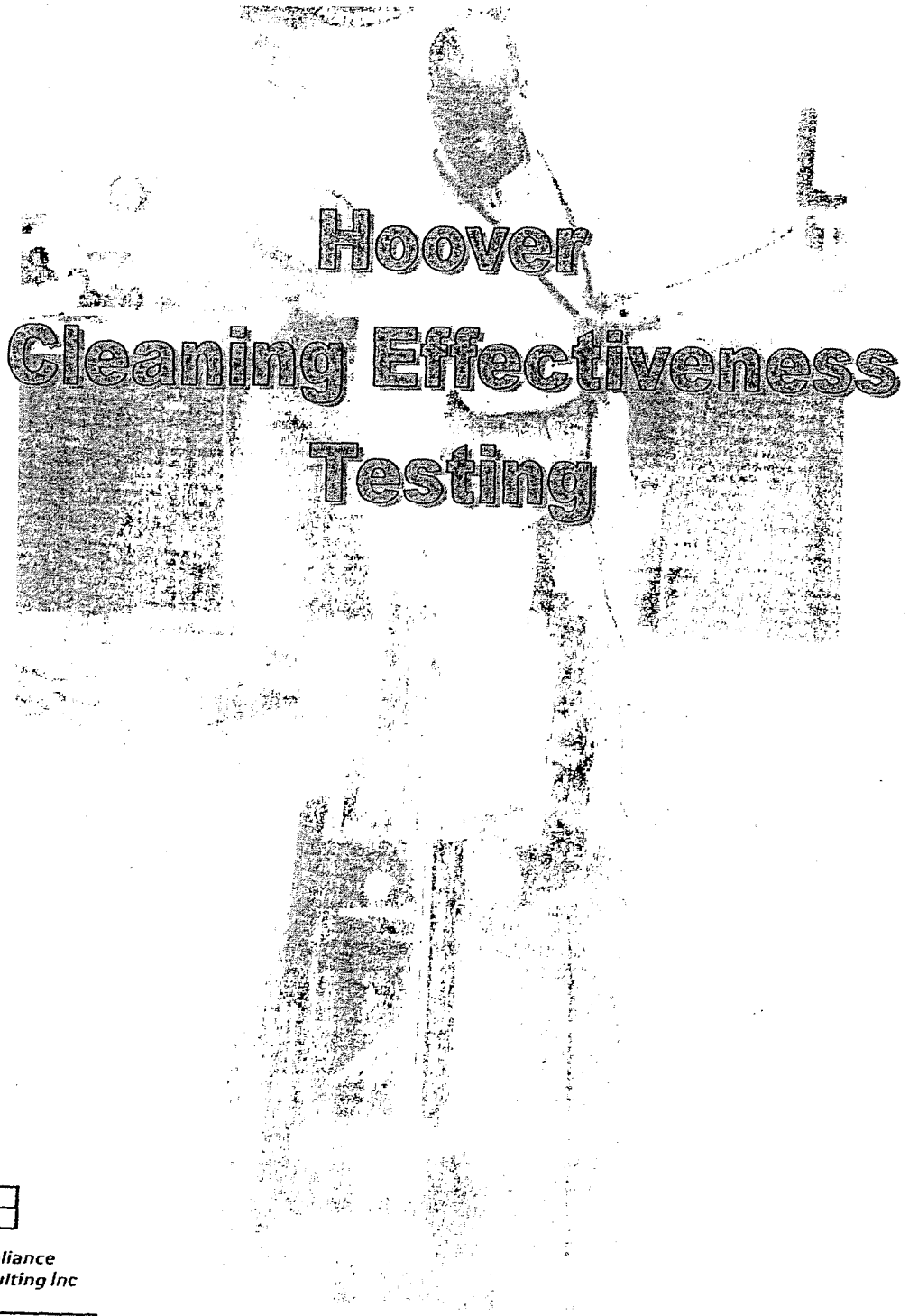

Compliance
Consulting Inc

Hoover

Cleaning Effectiveness Testing

7 to 25 February 2005

Compliance Consulting Inc

Cleaning Effectiveness Test Report

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Compliance Consulting Inc

Compliance Consulting Inc.
92 Tulip Grove Circle
Unit 16
Bristol, TN 37620

Test Report A05-02-001

Provided For:

The Hoover Company
101 East Maple Street
North Canton, OH 44720

General:

This test program was established to conduct comparison testing of the cleaning ability between nine separate upright vacuum cleaner models. For the purpose of this test report, the models of all vacuum cleaners have been coded. Testing was conducted at The Hoover Company in North Canton, Ohio between 7 February 2005 and 25 February 2005. Testing was witnessed by Compliance Consulting Inc.

Test Samples:

Eight separate model vacuum cleaners were tested. A minimum of three samples of each model were evaluated (See sample chart below). One model was tested in two separate configurations, both configurations being provided in the same package. Each configuration was treated as a separate model, thus yielding a total of nine models. All samples were provided by The Hoover Company in their original, unopened condition.

Samples Tested:

Unit 1 – Samples A, B, C, D^2, E^2
Unit 2 – Samples A, B, C, D^4, E^2
Unit 3 – Samples A, B^2, C, D
Unit 4 – Samples A, B^1, C, D
Unit 5 – Samples A, B^2, C^2, D, E, F^2
Unit 6 – Samples A^3, B, C^2, D, E^2, F^2, G
Unit 7 – Samples A, B, C, D^5, E^2, F^2, G^2, H^5
Unit 8 – Samples A, B, C, D^6
Unit 9 – Samples A, B, C, D^2, E^2

Notes:
1 - Due to proximity of serial numbers, unit not used for test. This unit replaced with unit 4D.
2 - Used for shag carpet only; needed to reach 90% confidence. Unit 7E used on multi-level and shag.
3 - Unit discarded because construction did not meet minimum production standards.
4 - Unit used to reach 90% confidence level on plush, multi-level and shag.

5 - Due to the unavailability of additional test samples, this unit had to be withdrawn in order to meet the 90% confidence level required by ASTM statistics.
6 - Unit used to reach 90% confidence level on multi-level.

Carpets Tested:

ASTM Plush - 08/2001
ASTM Multi-Level - 09/1990
ASTM Shag - 10/2004
ASTM Level Loop - 01/2005

Test carpets used were standard ASTM carpet panels manufactured in accordance with ASTM F655-03, Standard Specification for Test Carpets and Pads for Vacuum Cleaner Testing. The level loop and shag carpets were new carpets approved for use beginning in January 2005, in accordance with ASTM Subcommittee F11.21 meeting held during the October 2004 meeting of ASTM Committee F-11 for Vacuum Cleaners.

Equipment List:

Item	Manufacturer	Model Number	Serial Number	Cal Date	Cal Due
Power Analyzer	Yokogawa	WT-200	PT-11.070[1]	2-19-04	2-19-05
	Yokogawa	WT-200	CP-11.058[2]	1-7-05	1-7-06
Power Source	California Instruments	3000ix	N/A	7-16-04	7-16-05
Scale	Acculab	600	23390094	8-31-04	8-31-05
	Mettler	PE-16	E48897	8-31-04	8-31-05
T/H Recorder	Dickson	TH 8	CP-25.110	2-3-05	2-3-06
Stopwatch	Sportline	Alpha 410	Multiple	N/A[3]	N/A
°F Psychrometer	Cole-Palmer	3312-20	N/A	N/A	N/A
Barometer	L. Black Co	N/A	M-24.20	N/A	N/A
Embedding Tool	Custom built	35 lb. w/handle	N/A	N/A	N/A

Notes:
1 - Used through 17 February 2005
2 - Used after 17 February 2005
3 - Equipment Number PT-22.205 calibrated 4-26-04 (Used to check other stopwatches)

Test sample preparation:

Prior to removing the units, each package was weighed. Test samples were removed from their original packages and assembled by Hoover personnel in the presence of the CCI observer. As each sample was assembled, the sample information was recorded, and each sample received a unique sample number. Because procurement of some samples was difficult, due to models being on backorder, a serial number spread of 100 between samples was not always possible. In at least one case, a sample was withdrawn due to an insufficient serial number spread. Upon assembly, each sample was pre-conditioned at rated voltage

and rated frequency (120 V, 60 Hz) for a period of one hour. All samples were maintained in a test area that is locked during off hours.

Conditioning of the sample vacuum cleaners included a two-minute run-in period prior to testing, and again if not tested within a one-hour period. Test carpets were pre-conditioned each day and "topped off" if not used within a one-hour period. During the test series, two periods of carpet calibration were required. Carpet pre-conditioning records are attached.

Test Room:

The test room is environmentally controlled and maintained at a temperature of 70 ± 5°F and 50 ± 5% relative humidity. Environmental conditions were recorded on a chart recorder. Chart recorder sheets are attached. All test samples, carpets and test dirt were conditioned for a period of at least 16 hours in the test room prior to use.

Test Method:

Testing of the subject vacuum cleaners was conducted in accordance with ASTM Specification F608-03, Standard Test Method for Evaluation of Carpet Embedded Dirt Removal Effectiveness of Household/Commercial Vacuum Cleaners. The test dirt conforms to the requirements in ASTM F608.

Test Results:

Test data sheets were prepared in an Excel spreadsheet, and signed data sheets for each model cleaner are attached. The test results contained in this report are provided for evaluation by The Hoover Company. No opinions or conclusions are provided by Compliance Consulting Inc.

Addendum:

In order to meet the ASTM requirements for statistical accuracy it was necessary to return to the manufacturer on 7 March 2005 and test two additional samples (Units 7G and 7H) on shag carpet. The relevant portions of this test report have been revised to reflect this additional testing.

Cleaning Test Summary Data

	Plush	Multilevel	Shag	Level Loop	GM	vs Unit 1	vs Unit 2
1A	41.03	23.53	7.27	70.60	26.53		
1B	41.80	23.10	6.77	71.27	26.13		
1C	42.20	24.20	6.77	73.27	26.68		
1D			6.30				
1E			6.73				
Average	41.68	23.61	6.77	71.71	26.29	100%	92%
S	0.59	0.55	0.34	1.39	0.28		
A	2.080	1.180	0.340	3.590	1.31		
ts/sqrt(n)	0.990	0.930	0.320	2.340	0.47		
90% Conf Check	Pass	Pass	Pass	Pass	Pass		
2A	41.37	26.90	7.10	70.53	27.32		
2B	42.93	28.37	7.40	71.83	28.37		
2C	45.50	30.33	7.63	74.10	29.72		
2D	43.43	27.73	7.57				
2E		28.00					
Average	43.31	28.27	7.43	72.15	28.46	108%	100%
S	1.70	1.27	0.24	1.81	1.20		
A	2.166	1.414	0.372	3.608	1.42		
ts/sqrt(n)	2.000	1.211	0.282	3.051	2.02		
90% Conf Check	Pass	Pass	Pass	Pass	Fail		
3A	69.43	57.53	13.17	79.10	45.16		
3B			13.23				
3C	67.83	55.87	12.43	78.27	43.82		
3D	67.20	55.30	12.67	79.43	43.98		
Average	68.15	56.23	12.88	78.93	44.43	169%	156%
S	1.15	1.16	0.39	0.60	0.73		
A	3.408	2.812	0.644	3.947	2.22		
ts/sqrt(n)	1.939	1.956	0.459	1.012	1.23		
90% Conf Check	Pass	Pass	Pass	Pass	Pass		

Cleaning Test Summary Data

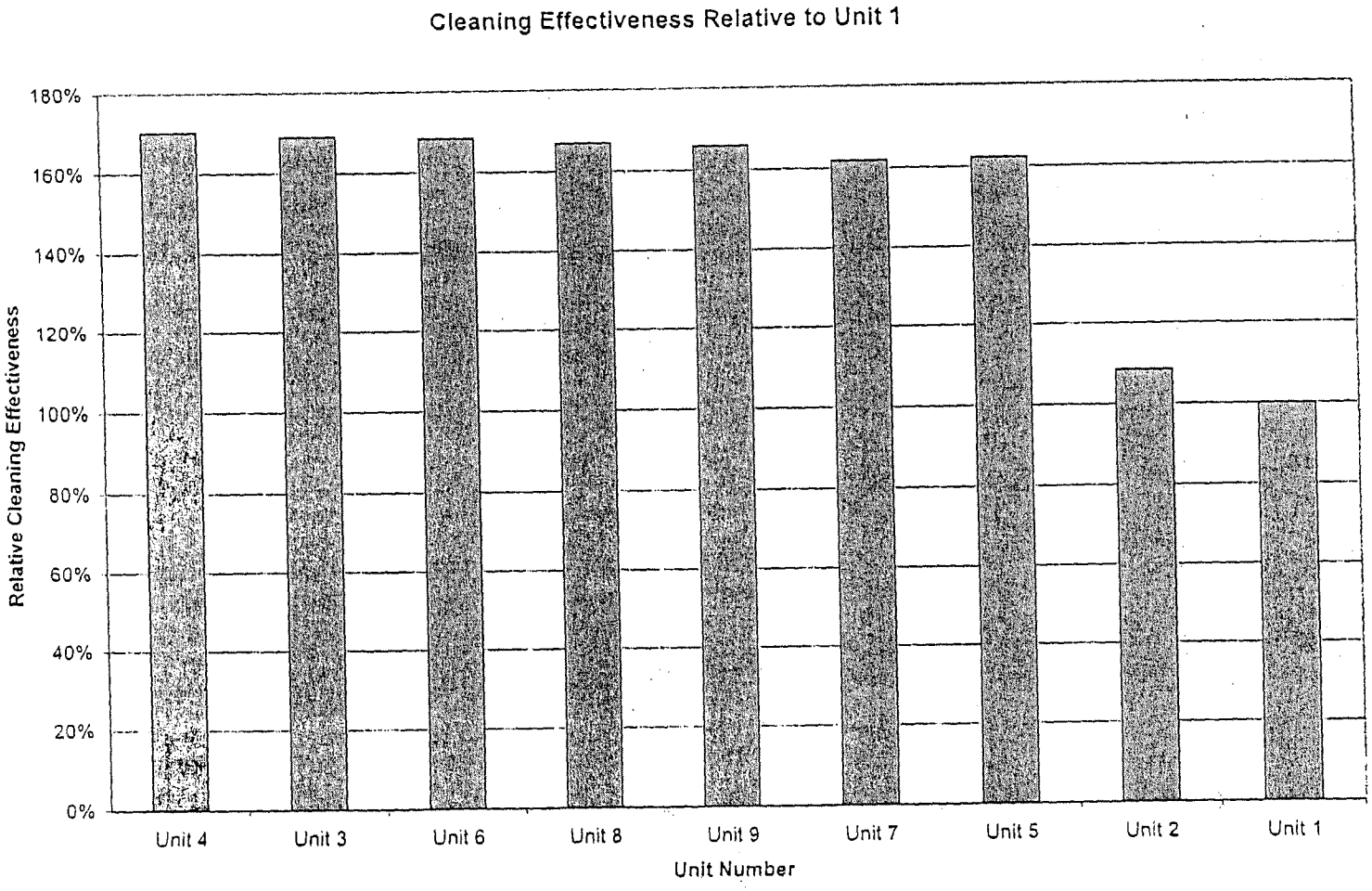
	Plush	Multilevel	Shag	Level Loop	GM	vs Unit 1	vs Unit 2
4A	67.80	56.10	12.87	78.27	44.24		
4C	69.50	58.07	13.50	78.33	45.45		
4D	68.60	57.00	13.13	78.20	44.76		
Average	68.63	57.06	13.17	78.27	44.82	170%	157%
S	0.85	0.99	0.32	0.07	0.61		
A	3.432	2.853	0.659	3.914	2.24		
ts/sqrt(n)	1.433	1.669	0.539	0.118	1.03		
90% Conf Check	Pass	Pass	Pass	Pass	Pass		
5D	65.43	58.10	9.50	84.60	41.81		
5A	64.87	60.10	10.87	81.07	43.05		
5E	64.27	58.97	10.40	83.17	42.55		
5B			10.83				
5C			10.20				
5F			10.67				
Average	64.86	59.06	10.41	82.95	42.65	162%	150%
S	0.58	1.00	0.52	1.78	0.62		
A	3.243	2.953	0.521	4.148	2.13		
ts/sqrt(n)	0.978	1.686	0.428	3.001	1.05		
90% Conf Check	Pass	Pass	Pass	Pass	Pass		

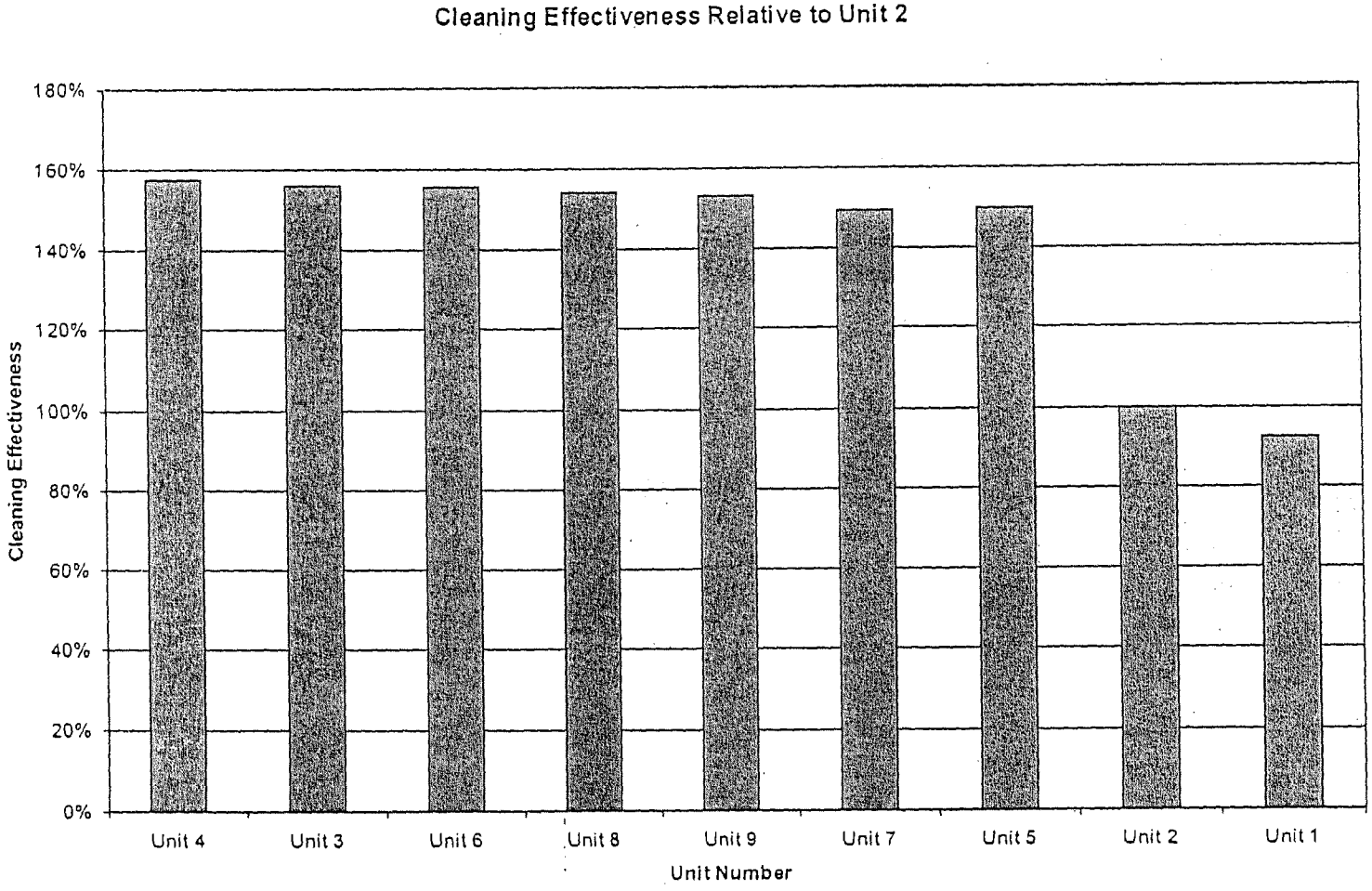
Cleaning Test Summary Data

	Plush	Multilevel	Shag	Level Loop	GM	vs Unit 1	vs Unit 2
~~6A~~	~~64.00~~	~~60.67~~	~~9.77~~	~~80.60~~	~~41.82~~		
6B	64.13	59.40	12.07	82.20	44.09		
6C			12.37				
6D	63.80	61.93	11.00	83.37	43.63		
6F			13.03				
6E			12.17				
6G	62.17	60.87	12.27	81.23	44.07		
Average	63.37	60.73	12.15	82.27	44.29	168%	156%
S	1.05	1.27	0.66	1.07	1.08		
A	3.169	3.037	0.608	4.114	2.21		
ts/sqrt(n)	1.770	2.141	0.543	1.804	1.27		
90% Conf Check	Pass	Pass	Pass	Pass	Pass		
7A	63.43	61.17	11.67	82.80	44		
7B	60.23	58.33	10.17	81.10	41.26		
7C	62.43	61.93	10.77	81.93	42.98		
~~7D~~		~~63.27~~	~~12.17~~				
7E		62.30	10.57				
7F			9.77				
7G			10.47				
~~7H~~			~~12.47~~				
Average	62.03	60.93	10.57	81.94	42.54	162%	149%
S	1.64	1.80	0.64	0.85	1.38		
A	3.102	3.047	0.529	4.097	2.13		
ts/sqrt(n)	2.765	2.118	0.526	1.433	2.33		
90% Conf Check	Pass	Pass	Pass	Pass	Fail		

Cleaning Test Summary Data

	Plush	Multilevel	Shag	Level Loop	GM	vs Unit 1	vs Unit 2
8A	66.13	63.13	12.50	78.83	45.04		
8B	63.30	59.03	11.83	77.63	43.04		
8C	62.77	60.90	12.03	77.23	43.41		
9D	[redacted]	62.60	[redacted]				
Average	64.07	61.42	12.12	77.90	43.9	167%	154%
S	1.810	1.850	0.340	0.830	1.06		
A	3.204	3.071	0.606	3.895	2.20		
ts/sqrt(n)	3.051	2.177	0.573	1.399	1.79		
90% Conf Check	Pass	Pass	Pass	Pass	Pass		
9A	63.60	61.70	12.93	78.03	44.61		
9B	61.63	60.23	11.80	75.73	42.68		
9C	65.00	61.73	12.43	77.43	44.33		
9D	[redacted]		11.73	[redacted]			
9E			11.63				
Average	63.41	61.22	12.10	77.06	43.62	166%	153%
S	1.69	0.86	0.56	1.19	1.04		
A	3.171	3.060	0.610	3.850	2.18		
ts/sqrt(n)	2.849	1.450	0.534	2.006	1.75		
90% Conf Check	Pass	Pass	Pass	Pass	Pass		


Cleaning Effectiveness Relative to Unit 1
Relative Cleaning Effectiveness
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
Unit 4
Unit 3
Unit 6
Unit 8
Unit 9
Unit 7
Unit 5
Unit 2
Unit 1
Unit Number


Cleaning Effectiveness Relative to Unit 2
Cleaning Effectiveness
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
Unit 4
Unit 3
Unit 6
Unit 8
Unit 9
Unit 7
Unit 5
Unit 2
Unit 1
Unit Number

Unit Summary

Unit No.	Plush	Multilevel	Shag	Level Loop	GM	vs DC14	vs DC07
Unit 4	68.63	57.06	13.17	78.27	44.82	170.5%	157.5%
Unit 3	68.15	56.23	12.88	78.93	44.43	169.0%	156.1%
Unit 6	63.37	60.73	12.15	82.27	44.29	168.5%	155.6%
Unit 8	64.07	61.42	12.12	77.90	43.90	167.0%	154.3%
Unit 9	63.41	61.22	12.10	77.06	43.62	165.9%	153.3%
Unit 7	62.03	60.93	10.57	81.94	42.54	161.8%	149.5%
Unit 5	64.86	59.06	10.41	82.95	42.65	162.2%	149.9%
Unit 2	43.31	28.27	7.43	72.15	28.46	108.3%	100.0%
Unit 1	41.68	23.61	6.77	71.71	26.29	100.0%	92.4%

Designation: F 608 – 03

An American National Standard

Standard Test Method for Evaluation of Carpet Embedded Dirt Removal Effectiveness of Household/Commercial Vacuum Cleaners[1]

This standard is issued under the fixed designation F 608; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers only a laboratory test for determining the relative carpet dirt removal effectiveness of household/commercial vacuum cleaners when tested under specified conditions.

1.2 This test method is applicable to household/commercial types of upright, canister, and combination cleaners.

1.3 The test method applies to embedded dirt removal from carpets, not the removal of surface litter and debris.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 75 Practice for Sampling Aggregates[2]

E 11 Specification for Wire Cloth Sieves for Testing Purposes[3]

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods[3]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[3]

F 655 Specification for Test Carpets and Pads for Vacuum Cleaner Testing[4]

F 884 Test Method for Motor Life Evaluation of a Built-In (Central Vacuum) Vacuum Cleaner[4]

F 922 Test Method for Motor Life Evaluation of an Electric Motorized Nozzle[4]

F 1038 Test Method for Motor Life Evaluation of a Canister, Hand-held, Stick, and Utility Type Vacuum Cleaner Without a Driven Agitator[4]

F 1334 Test Method for Determining A-Weighted Sound Power Level of Vacuum Cleaners[4]

F 1409 Test Method for Straight-Line Movement of Vacuum Cleaners While Cleaning Carpets[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *cleaning ability, dry, n*—the potential of a vacuum cleaner to remove dirt from a surface (sometimes referred to in the industry as *cleanability, dry*).

3.1.2 *model, n*—the designation of a group of vacuum cleaners having identical mechanical and electrical construction with only cosmetic or nonfunctional differences.

3.1.3 *population, n*—the total of all units of a particular model vacuum cleaner being tested.

3.1.4 *repeatability limit, r*—the value below which the absolute difference between two individual test results obtained under repeatability condition may be expected to occur with a probability of approximately 0.95 (95 %).

3.1.5 *repeatability standard deviation, S_r*—the standard deviation of test results obtained under repeatability conditions.

3.1.6 *reproducibility limit, R*—the value below which the absolute difference between two test results obtained under reproducibility conditions may be expected to occur with a probability of approximately 0.95 (95 %).

3.1.7 *reproducibility standard deviation, S_R*—the standard deviation of test results obtained under reproducibility conditions.

3.1.8 *sample, n*—a group of vacuum cleaners taken from a large collection of vacuum cleaners of one particular model which serves to provide information that may be used as a basis for making a decision concerning the larger collection.

3.1.9 *test run, n*—the definitive procedure that produces a singular measured result.

3.1.10 *unit, n*—a single vacuum cleaner of the model being tested.

4. Significance and Use

4.1 This test method provides an indication of the capability of the vacuum cleaner to remove embedded dirt from carpeting. This test method is based upon results of home cleaning tests so that, in most cases, a reasonable correlation exists between home and laboratory results. The amount of dirt picked up in the laboratory test may not be the same as in the

[1] This test method is under the jurisdiction of ASTM Committee F11 on Vacuum Cleaners and is the direct responsibility of Subcommittee F11.21 on Cleanability.
Current edition approved Oct. 1, 2003. Published October 2003. Originally approved in 1979. Last previous edition approved in 2001 as F 608 – 01.

[2] *Annual Book of ASTM Standards*, Vol 04.03.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] *Annual Book of ASTM Standards*, Vol 15.08.

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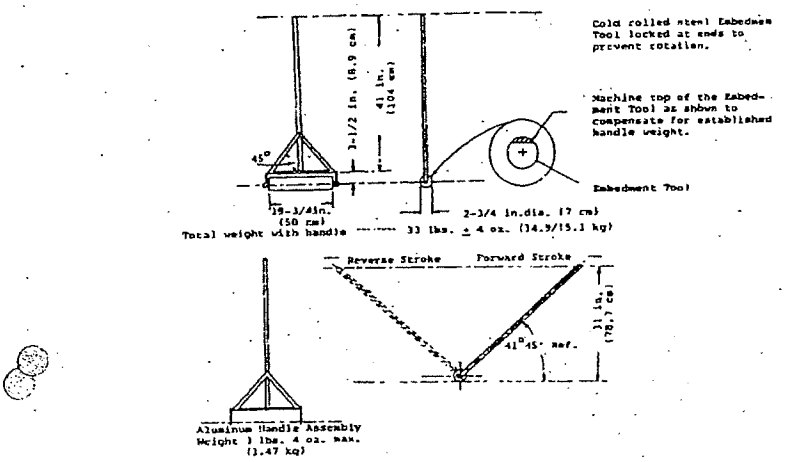

FIG. 1 Dirt Embedment Tool

home; however, it will show that, in most cases, a vacuum cleaner that performs well in the laboratory will perform well in a home. Laboratory results may differ due to variations in the homes, carpets, dirt, and other factors (see Section 6).

4.2 In order to provide a uniform basis for measuring the performance described in 1.1, standardized test carpets and a standardized test dirt are employed in this procedure.

5. Apparatus

5.1 *Weighing Scale for Weighing Carpets*, accurate to 0.035 oz (1 g) and having a weighing capacity of at least 15 lb (6.82 kg).[5]

5.2 *Weighing Scale (for Weighing Test Dirt and Dirt Container*, (see 10.2.1.2), accurate to 0.0035 oz (0.10 g) and having a weighing capacity of at least 1.1 lb (500 g).[6]

5.3 *Stopwatch*, with a second hand or other type of equipment capable of establishing the specified rate of movement and total cycle time.

5.4 *Voltmeter*, to measure input volts to the vacuum cleaner, to provide measurements accurate to within ±1 %.

5.5 *Voltage-Regulator System*, to control the input voltage to the vacuum cleaner. The regulator shall be capable of maintaining the vacuum cleaner's rated voltage ±1 % and rated frequency having a wave form that is essentially sinusoidal with 3 % maximum harmonic distortion for the duration of the test.

5.6 *Dirt Embedment Tool*, with the roller locked (see Fig. 1).

5.7 *Dirt Dispenser*—Dispensing system that provides the operator with a method to distribute the test dirt *uniformly* on the carpet test area.

5.8 *Carpet-Conditioning Equipment*, to support the test carpet during new carpet conditioning and the removal of residual dirt from the test carpet before each test run (Fig. 2).

5.9 *Rotating Agitator Conditioning Vacuum Cleaner/Equipment*, for conditioning new test carpets and removing residual dirt from the test carpet before each test run. This cannot be the unit being tested.

NOTE 1—Automated methods for spreading the test dirt, embedding the test dirt, and cleaning and reconditioning the test carpets are acceptable if they do not change the results of this test method.

5.10 *Temperature and Humidity Indicators*, to provide temperature measurements accurate to within ±1°F (±½ °C) and humidity measurements accurate to within 2 % relative humidity.

5.11 *Supporting Surface*—A flat surface consisting of a piece of ¾-in. (19-mm) thick exterior-grade plywood with the "A" surface upward to support the test carpet and pad. The test carpet and pad may be fastened to the supporting surface, but only the four corners, by any acceptable means.

5.12 *Rotating Agitator Reference Vacuum Cleaner*, one, for calibrating test carpets (see 10.4).

5.13 *Straight-Air Canister Reference Vacuum Cleaner*, one, for calibrating test carpets (see 10.4).

6. Materials

6.1 Standard carpets conforming to Specification F 655.

6.2 Standard carpet padding conforming to Specification F 655.

6.3 Test dirt (see Annex A1).

[5] The OHAUS Models GT-8000, LB30-CO and 1119D all available from OHAUS, Inc., Florham Park, NJ or equivalent, have been found suitable for this purpose. It is recommended that the scale read directly in grams.

[6] The Mettler-Toledo Model PM 2000, available from Mettler-Toledo, Inc. Box 71, Hightstown, NJ 08520, the OHAUS Model GT-8000 available from OHAUS, Inc. Florham Park, NJ or equivalent, have been found suitable for this purpose. It is recommended that the scale read directly in grams.

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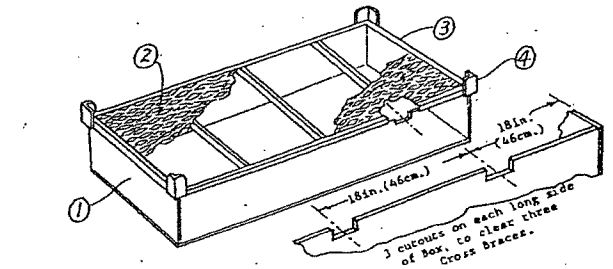
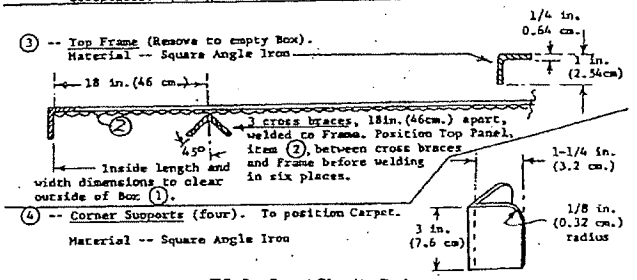


① -- Five Sided Box with open top.
Outside Dimensions, Length -- 72 in. (183 cm.)
Width -- 27 in. (69 cm.)
Depth -- 12 in. (30.5 cm.)
Material -- Plywood, 3/4 in. (1.9 cm.) thick.
Optional -- Bottom of box may be sloped downward to center opening to simplify emptying of test dirt accumulation.

② -- Flattened Expanded Steel Top Panel, .070 in. (1.8 mm) thick, with "75% open" area, and with diamond shaped openings:--
center-to-center, 2.1 in. (5.3 cm.) LWD
center-to-center, 0.93 in. (2.4 cm.) SWD
opening dimensions, 1.78 in. (4.5 cm.) LWD
opening dimensions, 0.688 in. (1.7 cm.) SWD
NOTE: Democr Style "3/4 in.-#13" material has been found to be acceptable. (Designer's Metal Div'n. of Southern Electric, Inc.)



③ -- Top Frame (Remove to empty Box).
Material -- Square Angle Iron

④ -- Corner Supports (four). To position Carpet.
Material -- Square Angle Iron

FIG. 2 Carpet Cleaning Rack

6.3.1 Silica sand (see Annex A1), and
6.3.2 Talc (see Annex A1).

7. Sampling

7.1 A minimum of three units of the same model vacuum cleaner selected at random in accordance with good statistical practice, shall constitute the population sample.

7.1.1 To determine the best estimate of cleaning ability effectiveness for the population of the vacuum cleaner model being tested, the arithmetic mean of the cleaning ability rating of the sample from the population shall be established by testing it to a 90 % confidence level within ±5 % of the mean value of the cleaning ability rating.

7.1.2 Annex A3 provides a procedural example for determining the 90 % confidence level and when the sample size shall be increased.

NOTE 2—See Annex A3 for method of determining 90 % confidence level.

8. Conditioning

8.1 *Test Room*—Maintain the test room in which all conditioning and vacuum cleaner testing is performed at 70 ± 5°F (21 ± 3°C) and 45 to 55 % relative humidity.

8.2 All components involved in the test shall remain and be exposed in the controlled environment for at least 16 h prior to the start of the test.

9. Test Carpets

9.1 New test carpets shall conform to Specification F 655.

9.1.1 Cut a sample of each test carpet to a size of 27 by 72 in. (690 by 1830 mm) minimum. If the warp direction or "lay" of the carpet can be determined, it shall be in the 72 in. direction as indicated in Fig. 3. Carpets shall be bound on all sides.

9.1.2 Mark the test area on each carpet as indicated in Fig. 3.

9.1.3 Precondition new test carpet samples.

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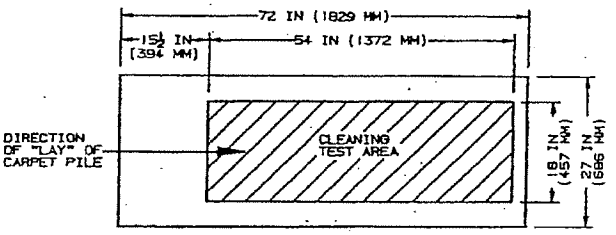

NOTE 1—Cleaning test area should be positioned as shown. First forward stroke of cleaner is in direction with "lay" of carpet.
FIG. 3 Test Carpet

9.1.3.1 Precondition the entire area of the carpet by cleaning with the rotating agitator conditioning vacuum cleaner. Continue the operation until less than 2 g of carpet fiber is picked up in 5 min.

9.1.3.2 Run ten carpet-embedded dirt removal effectiveness test runs in accordance with Section 12 before conducting test calibrations in accordance with Section 11.

9.1.4 Weigh and record the preconditioned weight of the carpet.

9.1.5 Run a test carpet calibration in accordance with Section 11.

9.2 *Reconditioning Used Test Carpet Samples:*

9.2.1 To remove the residual dirt and stabilize the moisture content, clean the carpet with a rotating agitator conditioning vacuum cleaner until its weight does not exceed its previously measured, original preconditioned weight (9.1.4) by more than 2 g and less than 1 g is picked up by the conditioning vacuum cleaner after 4 min of cleaning.

9.2.2 *Procedure:*

9.2.2.1 Clean the test carpet with the rotating agitator conditioning vacuum cleaner at a rate of 1.8 ft/s (0.55 m/s) as follows:

9.2.2.2 Place the carpet on the carpet cleaning rack (Fig. 2) with pile side down. Run the rotating agitator conditioning vacuum cleaner over the carpet for 2 min concentrating on the test area; then run the rotating agitator conditioning vacuum cleaner thoroughly over the entire carpet area at least one time.

9.2.2.3 Then place the carpet (nap up) on the pad, on the plywood supporting surface and clean it with the rotating agitator conditioning vacuum cleaner for 2 min, concentrating on the test area; then run the rotating agitator vacuum cleaner thoroughly over the entire area at least one time.

9.2.2.4 Weigh the carpet.

9.2.2.5 Keep alternating 9.2.2.2 and 9.2.2.3, always ending with pile side up, until the carpet weight meets the requirements of 9.2.1.

9.2.2.6 A high-cleaning performance rotating agitator vacuum cleaner is recommended for reducing the time to recondition the carpet.

9.2.2.7 Change the disposable primary filter after a maximum of every four runs on the conditioning vacuum cleaner or more often if required.

9.3 *Reconditioning Used Carpet Padding:*

9.3.1 Clean the carpet padding by shaking after each day's testing or more often, if necessary, to remove any collected dirt.

9.3.2 Replace the carpet padding when it has holes, tears, or other signs of wear.

10. Test Vacuum Cleaners

10.1 *New Test Vacuum Cleaners:*

10.1.1 *Preconditioning a New Test Vacuum Cleaner*—Run the vacuum cleaner in at rated voltage ±1 % and rated frequency with filters in place.

10.1.1.1 *Preconditioning Rotating Agitator Type Vacuum Cleaner*—In a stationary position operate the vacuum cleaner for 1 h with the agitator bristles not engaged on any surface.

10.1.1.2 *Preconditioning a Straight-Air Canister Vacuum Cleaner*—Operate the vacuum cleaner for 1 h with a wide-open inlet (without hose).

10.1.2 For vacuum cleaners with non-disposable dirt receptacles, weigh and record the receptacle's original weight to the nearest 0.0035 oz (0.10 g).

10.2 *Used Test Vacuum Cleaners:*

10.2.1 Recondition a used test vacuum cleaner; prior to each test run as follows:

10.2.1.1 Thoroughly remove excess dirt from the vacuum cleaner. Without using tools for disassembly, clean the entire outer surface, brushes, nozzle chamber, ductwork, inside of the chamber surrounding the primary filter, and inside hose and wands.

10.2.1.2 For vacuum cleaners using disposable filters as the primary filters, use a new disposable primary filter from the manufacturer for each test. Weigh the filter to the nearest 0.0035 oz (0.10 g) and install it as recommended by the vacuum cleaner manufacturer.

10.2.1.3 For vacuum cleaners using water as the primary filter, empty the receptacle and refill as recommended by the manufacturer.

10.2.1.4 For vacuum cleaners using non-disposable dirt receptacles, empty in accordance with the manufacturer's instructions after each test run and clean the receptacle until its weight is within 0.07 oz (2 g) of its original weight. Weigh the receptacle to the nearest 0.0035 oz (0.10 g) and install it as recommended by the vacuum cleaner manufacturer.

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10.3 *Test Vacuum Cleaner Settings*—If various settings are provided, set the motor speed setting, suction regulator, nozzle height, or combination thereof using the manufacturer's specifications as provided in the instruction manual for each type of carpet. Contact the manufacturer if no instructions are given, or if the instructions are unclear or inadequate.

10.3.1 All straight line movement (see Test Method F 1409), sound power (see Test Method F 1334), and motor life evaluation (see Specification F 655 and Test Methods F 884, F 922, F 1038) tests shall be conducted using the same settings (nozzle, motor speed, suction regulator, etc.) for each specific carpet.

10.4 *Reference Vacuum Cleaners (Calibration)*:

10.4.1 Use the reference vacuum cleaners only for determining the reference rating of carpets and for the verification of carpet acceptability (see Section 11).

10.4.2 Maintain the performance of the reference vacuum cleaners throughout the acceptable life of the carpet.

11. Test Carpet Calibration

11.1 The purpose of calibration is to determine when the test carpet needs to be replaced by establishing a reference rating for each new preconditioned test carpet and to check this rating every 50 or fewer test runs.

11.2 The reference ratings are determined for each test carpet by the percent pickup using the reference rotating agitator vacuum cleaner and the reference straight-air vacuum cleaner.

11.3 This percent pickup is determined by performing a carpet-embedded dirt removal effectiveness test (see Section 12).

11.4 Repeat the test carpet calibration procedure on the carpets every 50 or fewer test runs.

11.5 When the embedded dirt rating for either reference cleaner varies by 4 g from the original reference rating for the carpet, replace the carpet.

12. Carpet-Embedded Dirt Removal Effectiveness Test

12.1 Prepare test carpets in accordance with 9.1 for new carpets or 9.2 for used carpets.

12.2 Perform a calibration test, if required, in accordance with Section 11.

12.3 If preconditioning or reconditioning has been done more than 1 h before a test run, weigh the carpet. If the weight of the carpet exceeds the preconditioned or reconditioned weight by more than 2 g, clean the carpet with a rotating agitator conditioning vacuum cleaner until this criteria is met.

12.4 Position the test carpet on the padding (with "scrim" side of the padding up) on the supporting surface (see 5.11).

12.5 Prepare test cleaners and dirt receptacles in accordance with Section 10.

12.5.1 Weigh the prepared dirt receptacle (that is, dust bag or other primary filter device) prior to conducting the measurement test run. Record the weight to the nearest 0.0035 oz (0.10 g).

12.5.2 Install the primary filter as explained below:

12.5.2.1 For vacuum cleaners using disposable primary filters, install a primary filter from the manufacturer per their instructions.

12.5.2.2 For vacuum cleaners using water as the primary filter, empty and refill the receptacle as recommended by the vacuum cleaner manufacturer.

12.5.2.3 For vacuum cleaners using non-disposable primary dirt receptacles, clean the receptacle in accordance with 10.2.1.4 and install it per the manufacturer's instructions.

12.5.3 Ensure that the vacuum cleaner settings have been made in accordance with 10.3.

12.6 *Test Dirt Preparation*—Weigh and mix 3.17 ± 0.0035 oz (90 ± 0.1 g) of silica sand and 0.35 ± 0.0035 oz (10 ± 0.1 g) of commercial grade talcum, both conforming to the specifications found in Annex A1.

NOTE 3—Operator should view the Material Safety Data Sheets (MSDS) on both talc and silica sand before performing this test.

12.6.1 Silica sand shall be sieved to assure conformance to the specification of A1.2. Sieving shall be performed in accordance with Test Method D 75.

12.6.2 Bulk mixing and storage of sieved constituents of silica sand is acceptable if assay analysis meets the specification of A1.2.

12.6.3 Bulk storage of test dirt mixture (sand plus talc) is not allowed.

12.7 Distribute 3.52 oz (100 g) of the test dirt uniformly on the cleaning test area (see Fig. 3), using any convenient spreading method.

12.8 Embed the test dirt into the carpet using the dirt embedment tool shown in Fig. 1. Perform the embedding process by using a dragging motion in both directions with the handle held at the angle shown. Drag the dirt embedment tool over the test area exactly 30 strokes, alternating directions forward and back. (A movement in one direction is one "stroke.") Use a uniform movement to provide a "stroke" time of 2.5 s (a rate of 1.8 ft/s (0.55 m/s)). The first forward stroke shall be in the direction of carpet lay.

12.8.1 An acceptable laboratory practice shall be used to ensure that the dirt embedment tool shall not fall short of reaching the end boundaries of the test area, and the tool shall cover both side boundaries of the test area at all times.

12.9 Clean the embedding tool thoroughly.

12.10 Energize the cleaner for 2 min at nameplate rated voltage (±1 %) and frequency (±1 Hz) immediately preceding the test sequence of 12.11. For vacuum cleaners with dual nameplate voltage ratings, conduct testing at the highest voltage.

12.10.1 For a rotating agitator-type vacuum cleaner, place it such that the bristles clear the supporting surface and no loose dirt is picked up.

12.10.2 For a straight-air canister vacuum cleaner, operate with the rug tool unrestricted, positioned such that no loose dirt is picked up from the supporting surface.

12.11 Immediately following the 2-min "run-in" of 12.10, deenergize the vacuum cleaner and place the vacuum cleaner nozzle on the test carpet so that the front edge of the vacuum cleaner coincides with the line defining the beginning of the test area and the right side of the boundary of the 18-in. test width (see Fig. 4). The forward stroke of the nozzle shall be in the direction of the carpet lay (see Fig. 3).

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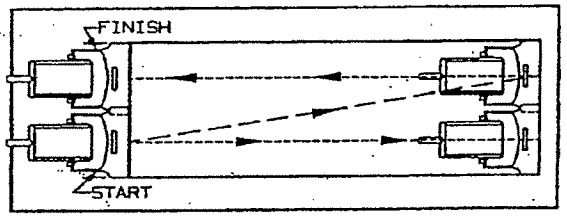

NOTE 1—This shows the nozzle positions for the cleaning pattern when $N = 2$. (Refer to Annex A2.)
FIG. 4 Cleaner Nozzle Position at Start and Finish of Test Cleaning Strokes

12.11.1 Reasonable efforts shall be made to maintain the handle height at 31.5 in. during each test run for vacuum cleaners with a pivoting handle.

12.11.2 Reasonable efforts shall be made to maintain the vacuum cleaner's nozzle parallel to the test carpet surface during each test run for vacuum cleaners with non-pivoting handles.

12.12 Tilt or lift the nozzle off the carpet, energize the vacuum cleaner, and adjust the voltage to rated voltage ±1 %. Allow the vacuum cleaner to run and expand the filter bag, if one is present.

12.13 *Test Cleaning Pattern*:

12.13.1 For a rotating agitator-type vacuum cleaner, lower the nozzle onto the carpet before the test area. Again, adjust the voltage to rated voltage ±1 %; then move the nozzle at a rate of 1.8 ft/s (0.55 m/s) in the test cleaning pattern and motion as specified in Annex A2 during the cleaning cycle. Maintain the nozzle position and settings as specified in 10.3 during the cleaning cycle.

12.13.2 For a straight-air vacuum cleaner, position the nozzle on the carpet before the test area. Again, adjust the voltage to rated voltage ±1 %; then move the nozzle at a rate of 1.8 ft/s (0.55 m/s) in the test cleaning pattern and motion as described in Annex A2. Maintain the nozzle position and settings as specified in 10.3 during the cleaning cycle.

12.14 At the end of the last stroke, smoothly tilt or lift the vacuum cleaner nozzle off the carpet and allow the vacuum cleaner to run approximately an additional 10 s to clear the system of test dirt actually picked up but temporarily trapped in it. Then deenergize the vacuum cleaner. During the additional run period, the hose used with the canister and combination vacuum cleaners should be flexed to help clear the system.

12.14.1 For vacuum cleaners with removable dirt receptacles, carefully remove the receptacle and weigh it. Record the weight to the nearest 0.10 g (0.0035 oz).

12.14.2 For vacuum cleaners using water as the primary filter, weigh the carpet to the nearest 1.0 g (0.035 oz).

12.15 Determination of the grams picked up for each test run will be done in the following manner:

12.15.1 For vacuum cleaners with removable dirt receptacles, subtract the weight of the clean dirt receptacle at the start of the test from the weight of the dirt receptacle at the end of the test. Record results to the nearest 0.10 g (0.0035 oz).

12.15.2 For vacuum cleaners using water as the primary filter, add 100 g (3.53 oz) to the weight of the carpet at the start of the test run and subtract the weight of the carpet at the end of the test run. Record results to the nearest 1.0 g (0.035 oz).

12.16 The percent carpet-embedded dirt removal effectiveness for a single test run of a given vacuum cleaner on a given carpet is the grams recorded in 12.15 divided by the 100 g, multiplied by 100.

12.17 Using the same test vacuum cleaner, repeat 12.1-12.16 two additional times for a total of three test runs.

12.18 The percent carpet-embedded dirt removal effectiveness for each individual test vacuum cleaner from the population sample is the average of three test runs meeting the repeatability statement in Section 13. See Annex A3 for a procedural example and whether further test runs need to be conducted.

12.19 A minimum of two additional test sample units of the same model shall be selected in accordance with the sampling statement of Section 7. Repeat 12.1-12.18 for each new test sample unit selected.

12.20 The percent carpet-embedded dirt removal effectiveness for the population of the vacuum cleaner model being tested is the arithmetic mean of the percent carpet-embedded dirt removal effectiveness from a sample of the population meeting the requirements of the sampling statement (Section 7).

13. Precision and Bias [7]

13.1 The following precision statements are based on interlaboratory tests involving six laboratories and two test units (one upright vacuum cleaner with agitator and one canister with straight-air floor tool).

13.2 The statistics have been calculated as recommended in Practice E 691.

13.3 The following statements regarding repeatability limit and reproducibility limit are used as directed in Practice E 177.

13.4 The standard deviations of repeatability and reproducibility of the measured results have been derived from twelve sets of data, where each of two sets of three test runs have been performed by a single analyst within each of the six laboratories on separate days using the same test unit.

13.5 *Repeatability (Single Operator and Laboratory; Multiday Testing)*—The ability of a single analyst to repeat the test within a single laboratory.

[7] Supporting data is available from ASTM Headquarters. Request RR: F11-1010.

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TABLE 1 Repeatability and Reproducibility

Type Carpet	Type Cleaner	Standard Deviation of Repeatability, S_r	Repeatability Limit, r	Standard Deviation of Reproducibility, S_R	Reproducibility Limit, R
Plush	Agitator	1.006	2.816	3.4122	9.554
	Straight Air	0.720	2.015	1.806	5.05
Multi-Level	Agitator	1.105	3.094	2.177	6.095
	Straight Air	0.934	2.615	3.929	11.000
Level Loop	Agitator	1.396	3.908	2.572	7.202
	Straight Air	1.320	3.696	6.581	18.428
Shag	Agitator	0.519	1.452	1.233	3.453
	Straight Air	0.160	0.448	0.366	1.025

13.5.1 The expected standard deviation of repeatability of the measured results within a laboratory, s_r, has been found to be the respective values listed in Table 1.

13.5.2 The 95 % repeatability limit within a laboratory, r, has been found to be the respective values listed in Table 1, where $r = 2.8(s_r)$.

13.5.3 With 95 % confidence, it can be stated that within a laboratory a set of measured results derived from testing a unit should be considered suspect if the difference between any two of the three values is greater than the respective value of the repeatability limit, r, listed in Table 1.

13.5.4 If the absolute value of the difference of any pair of measured results from three test runs performed within a single laboratory is not equal to or less than the respective repeatability limit listed in Table 1, that set of test results shall be considered suspect.

13.6 *Reproducibility (Multiday Testing and Single Operator Within Multilaboratories)*—The ability to repeat the test within multiple laboratories.

13.6.1 The expected standard deviation of reproducibility of the average of a set of measured results between multiple laboratories, s_R has been found to be the respective values listed in Table 1.

13.6.2 The 95 % reproducibility limit within a laboratory, R, has been found to be the respective values listed in Table 1, where $R = 2.8(s_R)$.

13.6.3 With 95 % confidence, it can be stated that the average of the measured results from a set of three test runs performed in one laboratory, as compared to a second laboratory, should be considered suspect if the difference between those two values is greater than the respective values of the reproducibility limit, R, listed in Table 1.

13.6.4 If the absolute value of the difference between the average of the measured results from the two laboratories is not equal to or less than the respective reproducibility limit listed in Table 1, the set of results from both laboratories shall be considered suspect.

13.7 *Bias*—No justifiable statement can be made on the bias of the method to evaluate carpet-embedded dirt removal effectiveness of household/commercial vacuum cleaners. Since the true value of the property cannot be established by an acceptable referee method.

14. Keywords

14.1 dirt removal; vacuum cleaners

ANNEXES

(Mandatory Information)

A1. TEST DIRT

A1.1 *Test Dirt*, 100 g, consisting of the following:

A1.1.1 *Item 1*—90 g of silica sand[a] in accordance with A1.2.

A1.1.2 *Item 2*—10 g of commercial grade talcum[b] in accordance with A1.3.

A1.2 Silica sand in the following particle size range and amounts:

Sieve Range, U.S. No.	Particle Size, μm	Amount Used, g
−30/+40	600–425	0.9
−40/+50	425–300	31.5
−50/+70	300–212	41.4
−70/+100	212–150	13.5
−100/+140	150–106	2.7

A1.3 Commercial grade talcum with the following particle size distribution:

Particle Size Range, μm	Distribution by Weight, %
>44	0.5
43.9 to 20	12.5
19.9 to 10	27.0
9.9 to 5	23.0
4.9 to 2	20.0
1.9 to 1	8.0
<0.9	9.0

[a] Wedron No. 540 Unground Silica Sand or the equivalent has been found satisfactory for this purpose. It is available from The Wedron Silica Co., Customer Service Department, P.O. Box 119, Wedron, IL 60557. The test dirt must be sieved to ensure conformance with the analysis limits. Use Test Method D 75.

[b] USP Grade Supreme Talc or the equivalent has been found satisfactory for the purpose. It is available from Fischer Scientific Co., 1600, West Glen Avenue, Box 171, Itasca, IL 60143.

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A2. TEST CLEANING PATTERN AND TIME

A2.1 *General*—All vacuum cleaners, regardless of the width of their nozzles, shall be moved back and forth in a specified pattern on the 54 by 18-in. (1370 by 460-mm) test area of the carpet for a total of exactly 16 strokes at the rate of 2.5 s per stroke, for a total time of 40 ± 1 s, using any acceptable laboratory method to assure that these specifications are met. Examples of methods that have been found acceptable are visible-marked timing belt or a stopwatch to measure stroke time and cumulative time.

A2.1.1 Measure the outside width of the nozzle housing in inches.

A2.1.2 Divide the nozzle width into 18 and round the result to the nearest larger whole number identified henceforth as *N*.

A2.1.3 Divide the width of test area (18 in.) into *N* equal strips and mark the test area accordingly. Note that for any vacuum cleaners having overall nozzle widths ranging from 3 to 17 in. the number of strips will be either 6, 5, 4, 3, or 2.

A2.1.4 Place the vacuum cleaner nozzle on the test carpet so that the front edge of the vacuum cleaner coincides with the line defining the beginning of the test area and the right side of the nozzle coincides with the right side boundary shown in the applicable illustration. Ensure that each forward stroke ends with the front edge of the vacuum cleaner coincident with the end of the test area. When the vacuum cleaner reaches the extreme left strip, align the left side of the nozzle with the left side boundary of the test area. See Fig. 4. This shows the pattern for $N = 2$. For variations of the pattern where $N = 2$ to $N = 6$, see Fig. A2.1. Take care to ensure that during each stroke, the side of the nozzle, right side or left side as applicable, is kept aligned with the side boundary of the test strip being cleaned, except for crossover strokes.

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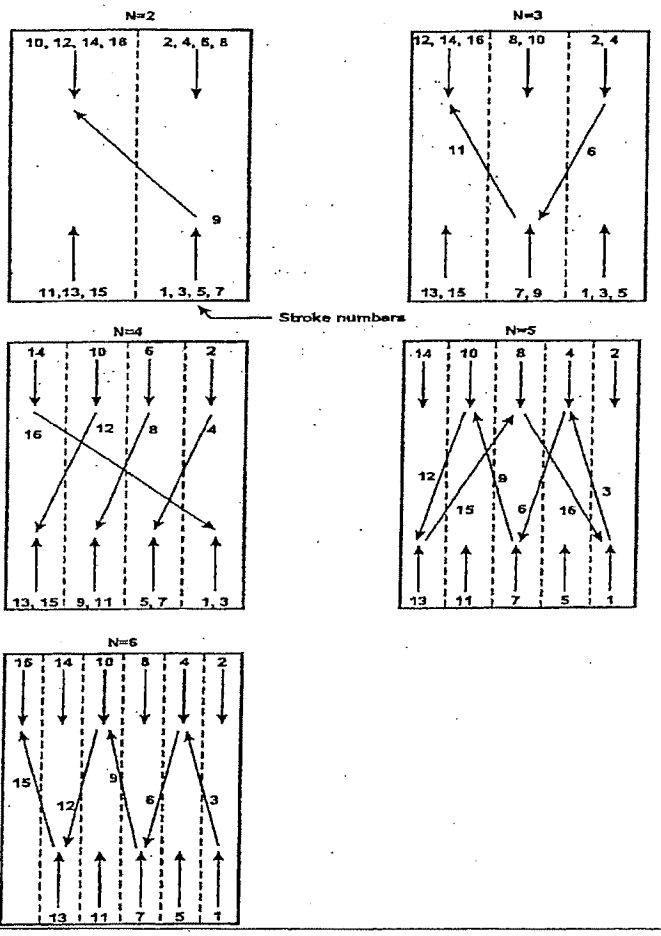

NOTE 1—The diagonal strokes shown in each pattern indicate that the test nozzle is moved from one stroke location to another during the diagonal stroke. There is no specific start or end point for the diagonal movement of the test nozzle during the diagonal stroke.

FIG. A2.1 Test Cleaning Patterns

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A3. DETERMINATION OF THE POPULATION MEAN HAVING A 90 % CONFIDENCE INTERVAL

TABLE A3.1 Percentiles of the *t* Distribution

df	$t_{0.95}$
1	6.314
2	2.920
3	2.353
4	2.132
5	2.015
6	1.943
7	1.895
8	1.860
9	1.833
10	1.812
11	1.796
12	1.782
13	1.771
14	1.761
15	1.753

A3.1 Theory

A3.1.1 The most common and ordinarily the best estimate of the population mean, μ, is simply the arithmetic mean, $\bar{X}$, of the individual scores (measurements) of the units comprising a sample taken from the population. The average score of these units will seldom be exactly the same as the population mean; however, it is expected to be fairly close so that in using the following procedure it can be stated with 90 % confidence that the true mean of the population, μ, lies within 5 % of the calculated mean, $\bar{X}$, of the sample taken from the population.

A3.1.2 The following procedure provides a confidence interval about the sample mean which is expected to bracket μ, the true population mean, $100(1-\alpha)\%$ of the time where α is the chance of being wrong. Therefore, $1-\alpha$ is the probability or level of confidence of being correct.

A3.1.3 The desired level of confidence is $1-\alpha = 0.90$ or 90 % as stated in Section 7. Therefore $\alpha = 0.10$ or 10 %.

A3.1.4 Compute the mean, $\bar{X}$, and the standard deviation, s, of the individual scores of the sample taken from the population:

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i \qquad \text{(A3.1)}$$

$$s = \sqrt{\frac{n\sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i\right)^2}{n(n-1)}}$$

where:

n = number of units tested, and

X_i = the value of the individual test unit score of the ith test unit. As will be seen in the procedural example to follow, this is the average value of the results from three test runs performed on an individual test unit with the resulting set of data meeting the repeatability requirements of Section 13.

A3.1.5 Determine the value of the t statistic for $n-1$ degrees of freedom, df, from Table A3.1 at a 95 % confidence level.

NOTE A3.1—The value of t is defined as $t_{1-\alpha/2}$ and is read as "t at 95 % confidence".

$$t \text{ statistic} = t_{1-\alpha/2} = t_{0.95} \qquad \text{(A3.2)}$$

where:

$1-\alpha/2 = 1-0.10/2 = 1-0.05 = 0.95$, or 95 %.

A3.1.6 The following equations establish the upper and lower limits of an interval centered about $\bar{X}$ that will provide the level of confidence required to assert that the true population mean lies within this interval:

$$CI_U = \bar{X} + ts/\sqrt{n} \qquad \text{(A3.3)}$$

$$CI_L = \bar{X} - ts/\sqrt{n}$$

where:

CI = confidence interval (U – upper limit; L – lower limit),

$\bar{X}$ = mean score of the sample taken from the population,

t = t statistic from Table A3.1 at 95 % confidence level,

s = standard deviation of the sample taken from the population, and

n = number of units tested.

A3.1.7 It is desired to assert with 90 % confidence that the true population mean, μ, lies within the interval, CI_U to CI_L, centered about the sample mean, $\bar{X}$. Therefore, the quantity $ts/\sqrt{n}$ shall be less than some value, A, which shall be 5 % of $\bar{X}$ in accordance with the sampling statement of 7.1.

A3.1.8 As $n \to \infty$, $ts/\sqrt{n} \to 0$. As this relationship indicates, a numerically smaller confidence interval may be obtained by using a larger number of test units, n, for the sample. Therefore, when the standard deviation, s, of the sample is large and the level of confidence is not reached after testing three units, a larger sample size, n, shall be used.

A3.2 Procedure

A3.2.1 A graphical flow chart for the following procedure is shown in Fig. A3.1.

A3.2.2 Select three units from the population for testing as the minimum sample size.

A3.2.3 Obtain individual test unit scores by averaging the results of three test runs performed on each of the three individual test units. The data set resulting from the three test runs performed on each individual test unit shall meet the respective repeatability requirement found in Section 13.

A3.2.4 Compute $\bar{X}$ and s of the sample.

A3.2.5 Compute the value of A where $A = 0.05(\bar{X})$.

A3.2.6 Determine the statistic t for $n-1$ degrees of freedom from Table A3.1 where n = the number of test units.

A3.2.7 Compute $ts/\sqrt{n}$ for the sample and compare it to the value to A.

A3.2.8 If the value of $ts/\sqrt{n} > A$, an additional unit from the population shall be selected and tested, and the computations of A3.2.3-A3.2.7 repeated.

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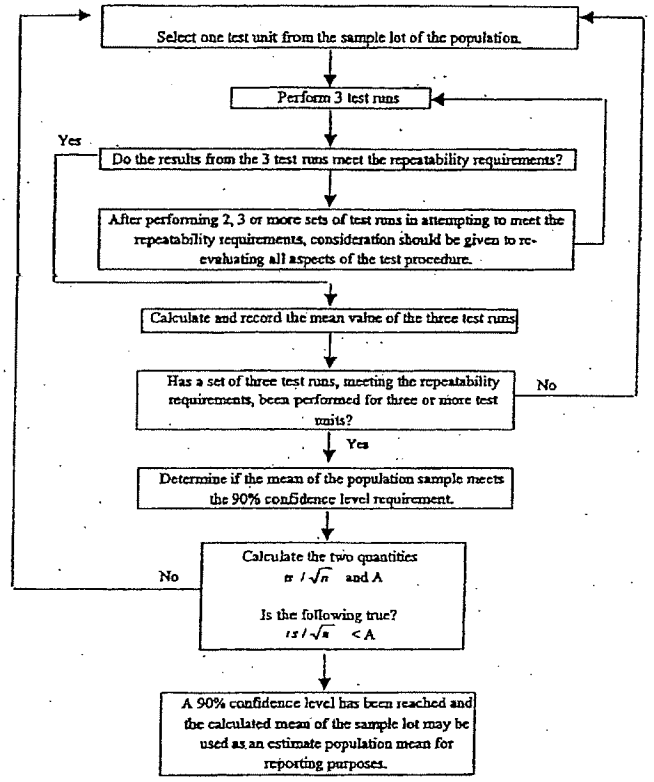

FIG. A3.1 Testing Procedure Flowchart

A3.2.9 If the value of $ts/\sqrt{n} < A$, the desired 90 % confidence level has been obtained. The value of the final $\bar{X}$ may be used as the best estimate of the cleaning ability rating for the population.

A3.3 Example

A3.3.1 The following data is chosen to illustrate how the value of embedded dirt cleaning ability for the population of an agitator type vacuum cleaner model, tested on ASTM Single-Level Loop carpet, is derived. For this particular carpet, the measured test results from three test runs on each unit are required to have a repeatability limit not exceeding 3.908 as indicated in Table 1.

A3.3.2 Select three test units from the vacuum cleaner model population. A minimum of three test runs shall be performed using each test unit.

A3.3.3 Test run scores for test unit No. 1:

test run No. 1 = 60.5
test run No. 2 = 62.7
test run No. 3 = 65.3

A3.3.4 Maximum spread = 65.3 – 60.5 = 4.8. This value is greater than the repeatability limit required in Table 1. The results shall be discarded and three additional test runs performed.

A3.3.5 Test run scores for test unit No. 1:

test run No. 4 = 64.9
test run No. 5 = 65.1
test run No. 6 = 65.8

A3.3.6 Maximum spread = 65.8 – 64.9 = 0.9. This value is less than the repeatability limit requirement of Table 1.

A3.3.7 Unit No. 1 score = (64.9 + 65.1 + 65.8)/3 = 65.27.

NOTE A3.2—If it is necessary to continue repeated test run sets (7, 8, 9–10, 11, 12—etc.) because the spread of data within a data set is not less

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than the repeatability limit requirement stated in Table 1, there may be a problem with the test equipment, the execution of the test procedure, or any of the other factors involved in the test procedure. Consideration should be given to reevaluating all aspects of the test procedure for the cause(s).

A3.3.8 A minimum of two additional test units must be tested, each meeting the repeatability limit requirement. For this procedural example, assume those units met the repeatability requirement and the individual unit scores are:

Score of test unit No. 1 = 65.27
Score of test unit No. 2 = 69.53
Score of test unit No. 3 = 67.41

A3.3.9 $\bar{X} = \frac{1}{3}(65.27 + 69.53 + 67.41) = 67.403$.

A3.3.10

$$s = \sqrt{\frac{3[(65.27)^2 + (69.53)^2 + (67.41)^2] - [65.27 + 69.53 + 67.41]^2}{3(3-1)}} \quad \text{(A3.4)}$$

$$s = 2.130$$

A3.3.11 $A = 0.05\ (67.403) = 3.370$.

A3.3.12 Degrees of freedom, $n - 1 = 3 - 1 = 2$; $t_{0.95}$ statistic = 2.920.

A3.3.13 $ts/\sqrt{n} = 2.920\ (2.130)/\sqrt{3} = 3.591$.

A3.3.14 3.591 > 3.370 The requirement that $ts/\sqrt{n} < A$ has not been met because s is larger. Therefore, an additional test unit from the population shall be tested.

A3.3.15 Score of test unit No. 4 = 66.82.

A3.3.16 $\bar{X} = \frac{1}{4}(65.27 + 69.53 + 67.41 + 66.82) = 67.258$.

A3.3.17

$$s = \sqrt{\frac{4[(65.27)^2 + (69.53)^2 + (67.41)^2 + (66.82)^2] - [65.27 + 69.53 + 67.41 + 66.82]^2}{4(4-1)}} \quad \text{(A3.5)}$$

$$s = 1.763$$

A3.3.18 $A = 0.05\ (67.258) = 3.363$.

A3.3.19 Degrees of freedom, $n - 1 = 4 - 1 = 3$; $t_{0.95}$ statistic = 2.353.

A3.3.20 $ts/\sqrt{n} = 2.353\ (1.763)/\sqrt{4} = 2.075$.

A3.3.21 2.075 < 3.363 (meets requirements).

A3.3.22 Thus, the value of $\bar{X}$, 67.26, represents the embedded dirt cleaning ability score for the vacuum cleaner model tested on the given carpet and may be used as the best estimate of the cleaning ability rating for the population mean.

APPENDIX

(Nonmandatory Information)

X1. IN-HOME CLEANING TEST

X1.1 Scope

X1.1.1 The purpose of this test is to determine a ratio of a carpet-embedded dirt removal effectiveness and a home-carpet embedded removal effectiveness rating which can be used for comparing one or more vacuum cleaners against a standard vacuum cleaner and determining correlation with laboratory CTM tests. The results are representative of the geographic area covered by the test homes.

X1.2 Summary of Method

X1.2.1 Each vacuum cleaner is tested in 25 homes in comparison with a standard vacuum cleaner. The grams of dirt picked up from the carpet in each home by each vacuum cleaner are accurately weighed. Each vacuum cleaner is manipulated over four segments of carpet 18 by 54 in. for 40 s per segment. The ratio of carpet-embedded dirt removal effectiveness equals the ratio of dirt picked up by the test vacuum cleaner (*B*) divided by dirt picked up by the standard vacuum cleaner (*A*). The home vacuum cleaning effectiveness rating of vacuum cleaner (*B*) to that of vacuum cleaner (*A*) is the geometric mean of the values obtained in the 25 individual tests performed.

X1.3 Significance

X1.3.1 The ratio of carpet-embedded dirt removal effectiveness for specific vacuum cleaner determined by "in-home" tests can be compared to "in-laboratory" tests for correlation.

X1.4 Apparatus

X1.4.1 *Standard Vacuum Cleaner for Comparison*, either upright or canister.

X1.4.2 *Frame*, inside effective area 18 by 54 in. (see Fig. X1.1):

X1.4.3 *Stop Watch.*

X1.4.4 *Canister Vacuum Cleaner*, for conditioning vacuum cleaners between tests and for finishing cleaning the remaining test area.

X1.4.5 *Dust Bags*, for appropriate vacuum cleaners.

X1.4.6 *Polyethylene Bags*, for sealing and transporting dust bags.

X1.4.7 *Balance Scale*, for weighing dust bags to within ±0.01 g.

X1.4.8 *Test Vacuum Cleaner.*

X1.4.9 *Homes*, 25 with carpeted area for selecting 6 ft area. This area must not be obstructed to traffic by furniture or scatter rugs, test homes should be randomly located throughout the graphic test area.

X1.4.10 *Adjustable Transformer*, for adjusting or controlling a voltage to the vacuum cleaner.

X1.4.11 *Voltmeter*, to measure input volts to the vacuum cleaner, provide measurements accurate to within ±1 %.

X1.4.12 *Ammeter*, to measure input current to the vacuum cleaner, provide measurements accurate to within ±1 %.

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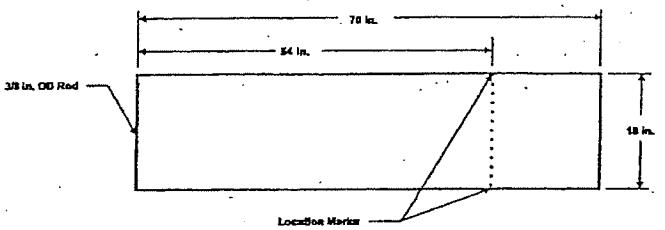

FIG. X1.1 Frame for In-Home Cleaning Test

X1.4.13 *Manometer* (or equivalent pressure-sensing device), to ensure sealed suction of the vacuum cleaner, to provide measurements in inches of water accurate to within ±0.10 in.

X1.4.14 *Tachometer(s)*, to measure motor speed in rpm and to ensure speed of agitator brush in rpm, accurate to ±1 %.

X1.5 Procedure

X1.5.1 Identify standard unit and test unit such as model number, serial number, and unit test number.

X1.5.2 *Initial Performance Check*—Check the test vacuum cleaner and the reference vacuum cleaner in the laboratory prior to the test, for functional properties. For this test, operate each vacuum cleaner at rated voltage on the ASTM Plenum Chamber using a 1¼-in. diameter orifice for upright vacuum cleaners and a ¾-in. diameter orifice for canister vacuum cleaners. Record: input current in amperes, motor speed in rpm, agitator speed in rpm, sealed suction, and agitator brush extension.

X1.5.3 Each day prior to testing in the home, check sealed suction, amperes, and brush rpm.

X1.5.4 Each vacuum cleaner is tested in 25 homes, in comparison to a standard vacuum cleaner. The test area is a 9 by 6-ft area made up of eight sections, each 18 by 54 in. (see Fig. X1.2). Areas *A* are cleaned by the known standard vacuum cleaner. Areas *B* are cleaned by the vacuum cleaner being tested. Bulky litter, such as hair pins, string, paper, etc., should be removed manually from the test area. The nozzle heights on the test and reference vacuum cleaners should be set in accordance with the specification under "Test Vacuum Cleaner Setting" in this test method.

X1.5.5 Each segment (A_1 or A_2 or B_1, etc.) should be cleaned using the same pattern of strokes, stroke time, and total time as established in this test method.

X1.5.6 The sequence of cleaning the segments of the carpet test area should be A_1, A_2, A_3, then A_4 with the standard vacuum cleaner, then B_1, B_2, B_3, then B_4 with the test vacuum cleaner.

X1.5.7 Use the frame as a guide for cleaning the 18 by 54-in. segment.

X1.5.8 Locate the test area with regard to some reference point in the home and sketch the alternative test segments *A* and *B*. Identify the carpet as to fiber, pile height, and type. Also record if padding is used under the carpet in each home tested, and the type of padding (rubber, foam, or felt).

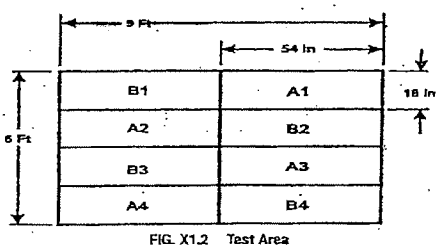

FIG. X1.2 Test Area

X1.5.9 Prior to leaving the laboratory, weigh each dust bag to the nearest ±0.01 g and record. Seal the dust bag in a polyethylene bag. Install the bag in the vacuum cleaner just prior to test. After the test, reseal the bag for transporting until time for second weighing. Then reseal and retain the bag until test is completed.

X1.5.10 Vacuum out each test unit prior to running each home test with a standby vacuum cleaner. In the case of a canister test, vacuum out the hose, wands, and nozzle between each test.

X1.5.11 Determine the dirt weight in the dust bag for the standard and for the test vacuum cleaner.

X1.6 *Data Treatment:*

X1.6.1 The ratio of carpet embedded dirt removal effectiveness for a single home is equal to the dirt picked up by Vacuum Cleaner *B* from areas $B_1 + B_2 + B_3 + B_4$ divided by the dirt picked up by Vacuum Cleaner A from areas $A_1 + A_2 + A_3 + A_4$ and is calculated as follows:

$$\text{Cleaning Effectiveness Ratio} = B/A \qquad \text{(X1.1)}$$

$$A = (A_1 + A_2 + A_3 + A_4)$$

$$B = (B_1 + B_2 + B_3 + B_4)$$

X1.6.2 The home cleaning effectiveness rating of Vacuum Cleaner B to that of Vacuum Cleaner A is the geometric mean of the values obtained in the 25 individual tests performed.

X1.7 *Cleaning Effectiveness Rating:*

$$\sqrt[N]{\left(\frac{B_1}{A_1}\right)\left(\frac{B_2}{A_2}\right)\left(\frac{B_3}{A_3}\right)\cdots\left(\frac{A_N}{B_N}\right)} \qquad \text{(X1.2)}$$

where N = number of homes in which this test was conducted.

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